AMENDMENTS TO THE SPECIFICATION

Please replace paragraph **[0023]** with the following amended paragraph:

[0023] In one embodiment, programmable rate controller 260 includes a variable bit rate (VBR) rate controller 280, a constant bit rate (CBR) rate controller 290, and a selector (not shown) for selecting an output from either the VBR rate controller 280 or the CBR rate controller 290. In one embodiment, the selector 510 <u>(FIG. 5)</u> picks the rate controller having the largest quantization step size as the output. VBR rate controller 280 permits a variable bit rate mode of operation. CBR rate controller 290 permits a constant bit rate mode of operation. For CBR rate controller 290 the target average and target peak bit rates are the same. For VBR rate controller 280 the target average and target peak bit rate may be set independently.

Please replace paragraph **[0026]** with the following amended paragraph:

[0026] Programmable rate controller 260 includes a parameter select input 215 for defining parameters to adjust the function of programmable rate controller 260. As described below in more detail, certain constraints such as the size of the video bitstream verification (VBV) buffer and the peak rate may be selected to guarantee MPEG-2 compliance and/or playback on a specified device, such as a VCD or DVD player. Other constraints, such as <u>the</u> target long-term average bit-rate may be imposed so that applications can predict and/or pre-allocate the size of the output bitstream prior to encoding. Examples of programmable rate control parameters include a target average bit rate, Ravg; a maximum bit rate, Rpeak, corresponding to a maximum bit rate specified in the header of the bitstream used by <u>the</u> video bitstream verification model <u>described below in more detail</u>; a bit rate time constant, τ, for adjusting VBR operation to deviations in average bit rate; a VBV buffer size, Bvbv in bits; a target quantizer scale, Qtarget for all macroblocks used by the VBR rate controller; an initial quantizer scale, Q0 for the VBR rate controller; a minimum quantizer scale value, Qmin, a lower bound on the target VBR quantizer scale value; and a maximum quantizer scale value, Qmax, an upper bound on <u>the</u> target VBR quantizer scale value for a picture. Additionally, other parameters, such as a dither update period, and a picture weighting factor may be selected. In

one embodiment, if a constant rate flag is set, a VBV-delay field of the picture will be encoded with a non-0xFFFF value for MPEG-2 bitstreams, resulting in true MPEG CBR streams with zero stuffing. It will also be understood that enable/disable signals may be included to enable or disable the CBR rate controller or the VBR rate controller. Some of these parameters are further described in Appendix 1, along with some of the associated limitations in independently setting these parameters caused by the inter-relationship of bit rate, quantizer size, image quality, and image complexity.

Please replace paragraph **[0028]** with the following amended paragraph:

[0028] It will be understood that the programmable rate controller 290 implements separate rate-quantization models for quantization-dependent and quantization-independent bits. Quantization-dependent bits are encoded bits that vary directly with the quantization step size. For intra blocks, quantization-dependent bits are those bits resulting from the encoding of the AC DCT coefficients. For non-intra blocks, quantization-dependent bits are those bits resulting from the encoding of all DCT coefficients. In both cases, quantization-dependent bits exclude bits resulting from the encoding of motion vectors, headers, and skipped macroblocks. Quantization-independent bits are all non-quantization-dependent bits in a picture. The CBR rate controller 290 creates running estimates for the number of quantization -independent bits in a picture independently for each picture type. The estimates are simply the output of a simple first-order infinite impulse response (IIR) filter operating on the past totals of quantization-dependent bits from pictures of the same type.

Please replace paragraph **[0029]** with the following amended paragraph:

[0029] Picture analysis module 310 classifies macroblocks by macroblock type and computes a statistical measure, called an energy value, indicative of the number of bits required to encode macroblocks of each type. Picture analysis module 310 receives as inputs input image data 1, motion-compensated difference image data 2, and macroblock coding decision data 3 for picture i. A table listing some of the variables used in the rate quantization models is included in Appendix 2. A summary of some of the signals in the rate controller is included in Appendix 3.

Please replace paragraph **[0039]** with the following amended paragraph:

[0039] Referring to Figure 3, in one embodiment picture analysis module <u>310</u> also generates an intra energy output 8 for use by bit allocation module 330 to improve bit prediction inside a VBV compliance check. As described below in more detail, intra energy output 8 is used by bit allocation module 330 to help anticipate sudden changes in picture complexity that otherwise might lead to VBV underflow and overflow. Picture analysis module 310 measures the intra energy, $E_{intra}(i)$, for the current picture by summing the energies of the original pixels for each macroblock in the image. This measurement is useful because I-frames are typically 12 to 15 frames apart. This measurement is combined with previous intra energy estimates to generate a current energy estimate for I-pictures, which may be updated using the following first-order IIR filter equation:

$$\overline{E}_{intra}(i) = \alpha(i) \cdot \overline{E}_{intra}(i-1) + (1-\alpha(i)) \cdot E_{intra}(i)$$

Please replace paragraph **[0043]** with the following amended paragraph:

[0043] Complexity model module 320 calculates an estimate <u>of</u> the complexity of the picture, which as described below in more detail, can be used by bit allocation module <u>330</u> to adjust the target bit rate. The actual complexity, $X(i)$, of the current picture (as determined after encoding) can be calculated from the encoding complexity, $x_k(i)$, of individual macroblocks, according to the equation:

$$X(i) = \sum_{k \in K} \Gamma_k(i) \cdot x_k(i)$$

Please replace paragraph **[0046]** with the following amended paragraph:

[0046] Bit allocation module 330 receives complexity model data 9 from complexity model module 320, intra-energy estimates [9]<u>8</u> from picture analysis module 310, and VBV fullness data 6 from variable length encoder 250. The complexity model data is used to generate

an estimate of an ideal target bit rate, which is then adjusted using the intra-energy estimates and VBV fullness data to maintain VBV fullness and compliance within acceptable limits.